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INVESTIGATIONS OF THE INFLUENCE OF HEAVY MUSCULAR WORK ON RENAL CAPACITY

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INVESTIGATIONS OF THE INFLUENCE OF HEAVY MUSCULAR WORK ON RENAL CAPACITY /142*

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ABSTRACT. Investigations on the influence of heavy muscular work on renal function, using the blood-urea clearance method, are discussed briefly with a tabulation of results obtained on 10 healthy test subjects during rest and heavy muscular work. Muscular work greatly influenced the urea clearance and caused a drop in renal function by as much as 25 - 75%. Water excretion, presumably by extrarenal processes, is influenced to a greater and more lasting extent than the urea excretion function. It is suggested to make urea clearance tests for diagnostic purposes only at bed rest.

Numerous observations exist on changes in urine secretion under the influence of heavy muscular work. No quantitative investigations on the renal capacity, using a method independent of extrarenal influences, are known from the literature. Therefore, it seemed desirable to measure the renal function during heavy physical work, using the clearance method by van Slyke. The tests were made with volunteer physical education students of the Königsberg Institute for Physical Education.

We used the following experimental arrangement: The urea clearance (maximum clearance) was determined after onset of a water diuresis, in periods of 15 min, during rest, during work, and after work. On another day, a control test was made with the same test subject under exactly equal conditions, determining the urea clearance at rest three times in succession.

The healthy and well-trained test subjects were given, on the fasting stomach, 1250 cc water with the juice of one and a half lemons, with a small amount of sugar added as taste corrigent. The total quantity of water was ingested within a period of 10 min. After this, the subjects were kept at bed rest; 50 min after drinking the mixture, the bladder was spontaneously and completely emptied. Following this, the urine was eliminated completely and punctually at three subsequent intervals of 15 min, collecting the entire specimen each time. At the middle of each period, blood was taken from an uncongested cubital vein, for urea analysis. During the tests, physical work was done continuously during the second period, using two dumbbells of 1.5 kg weight each, mainly by pushup and knee bends with arms and one leg extended. Special attention was paid to having arm, trunk, and leg musculature stressed uniformly and

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* Numbers in the margin indicate pagination in the foreign text.

continuously. This work resulted in almost all test subjects in considerable muscular aches.

Determination of the urea was done according to the method developed by H.A.Krebs (Ref.26), using a Warburg apparatus. The blood test was made with 1 cc citrate plasma. The thermobarometer contained physiological salt solution with 2% sodium citrate. The urine was diluted until about 1/1000 of the quarter-hour amount remained in 2 cc of the solution. This caused liberation of carbon dioxide in amounts of 50 - 300 mm^3 during the analysis due to urea splitting, i.e., the optimum amount for determination. The obtained urea values are given in cubic millimeters of gas. Here, 1 millimol (60 mg) urea corresponds to one milliequivalent gas (22,400 mm^3). Thus, 1 mg urea equals 373 mm^3 gas.

Calculation of the "maximum clearance" was done in the known simple manner: /143

$$\frac{mm^3 \text{ urea in urine volume/min}}{mm^3 \text{ urea in 1 cc blood}}.$$

In a few cases, the amount of urine, after muscular work, dropped below a value of 2 cc/min. In these cases, the standard clearance was calculated and multiplied by a factor $\frac{75}{54}$ so as to render the values comparable (normal value of maximum clearance C_m = 75 cc, normal value of standard clearance C_s = 54 cc). The respective numerical values are denoted by an asterisk.

After it was found that the fluctuations in blood-urea concentration were extremely minor during the short test period and under the influence of muscular work, only one blood sampling was done in later experiments so as to spare the subjects, using it as basis for calculating the three clearance values.

The test results are given in tables and show the following:

The urea content of the blood fluctuated only little during the experimental period and was not influenced by the muscular work. Conversely, its level differed considerably in the various test subjects. As a minimum, we found a value of 50 mm^3 in 1 cc, corresponding to 13.4 mg% urea respectively 6.25 mg% urea nitrogen. The maximum value was 181 mm^3, corresponding to 48.5 mg% urea or 22.6 mg% urea nitrogen.

The urea concentration in the urine is an arbitrary factor, determined by the excreted amount of water. For this reason, this concentration has been omitted from all of our tables. The numerals in the tables refer to the rate of urea secretion, given in cubic centimeters per minute (0.373 cc = 1 mg urea). The maximum value was 41 mg/min, corresponding to a daily conversion of about 60 gm urea or 28 gm urea nitrogen. The minimum value, under normal conditions, was 13 mg/min which corresponded to a daily amount of 8.95 gm urea, i.e., to the Rubner protein minimum.

Under the influence of muscular work, the urea elimination dropped far below this limit. The lowest observed excretion after muscular work was 2.1 mg urea/min.

	State	Amount of Urine cc/min	Urea cc/min	Blood-U+ mm³ in 1 cc	Clearance cc/min
	Test subject Pet.				
Work test	Rest	6.00	9.60	–	114
	Work	0.76	1.93	84	40*
	Afterperiod	1.27	4.87	87.5	77.5*
Control test	Rest	10.00	10.70		101
	Rest	7.66	7.66	106	72.5
	Rest	8.00	7.37		70
	Test subject Bra.				
Work test	Rest	20.0	9.60	84	115
	Work	7.66	3.64	72	50.5
	Afterperiod	4.46	6.15	88.5	70
Control test	Rest	16.70	825	74.5	112
	Rest	16.70	7.00	84.5	83
	Rest	14.00	6.37	82	78
	Test subject Sei.				
Work test	Rest	15.33	8.90	76	117
	Work	0.50	0.87	68	25*
	Afterperiod	0.44	0.79	72	21*
Control test	Rest	8.40	6.35	75.5	84
	Rest	11.65	7.35	84.0	87.5
	Rest	3.61	5.95	79.5	75
	Test subject Petz.				
Work test	Rest	5.33	13.70		104
	Work	5.74	9.06	131.5	69
	Afterperiod	10.20	11.70		89
Control test	Rest	2.27	15.35		85
	Rest	6.33	14.00	181	77.5
	Rest	11.33	14.40		79.5
	Test subject Ben.				
Work test	Rest	4.70	6.80	96.0	73
	Work	2.90	4.50	104.0	45.8
	Rest	0.53	4.05	102.0	66.5*
Control test	Rest	8.00	8.80	99.0	89
	Rest	8.70	7.62	93.5	82
	Rest	6.68	6.68	103.0	65
	Test subject Kah.				
Work test	Rest	4.67	9.36	83	92
	Work	4.40	6.26	79.5	60.5
	Rest	5.00	6.63	75.5	65
Control test	Rest	2.84	7.28	70	104
	Rest	2.34	6.12	70	87.5
	Rest	0.83	5.75	66.5	86.5*
	Test subject Nau.				
Work test	Rest	4.66	9.70		105
	Work	1.66	2.96	92	34.5*
	Afterperiod	1.27	5.48		82*
Control test	Rest	0.80	6.64		101*
	Rest	2.66	6.60	92	72
	Rest	10.01	7.60		82.5
	Test subject Rei.				
Work test	Rest	8.67	6.72	74	91
	Work	2.67	2.67	72	37
	Afterperiod	0.61	1.60	76	30.5*
Control test	Rest	8.66	5.72		65.5
	Rest	13.33	5.02	87.5	57.5
	Rest	14.33	4.85		55.5

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	State	Amount of Urine cc/min	Urea cc/min	Blood-U+ mm³ in 1cc	Clearance cc/min
		Test subject Ber.			
Work test	Rest	20.70	4.90	57.5	85
	Work	5.33	2.38	55.5	43
	Rest	1.73	2.36	51.3	46
Control test	Rest	7.20	8.35	108	77
	Rest	11.20	9.95	106	94
	Rest	6.70	7.35	111	66.5
		Test subject Hel.			
Work test	Rest	14.66	7.30	82.6	88.5
	Work	1.30	1.16	73	19.5*
	Rest	0.66	1.01	73.5	23.0*
Control test	Rest	6.87	6.45	54	119
	Rest	10.30	5.37	50.5	106
	Rest	—	—	49	—

In calculating the clearance values, the individual differences in the urea content of the blood and urine cancel out. The number of cubic centimeters of blood, eliminated through the kidneys in unit time, show only a minor individual fluctuation. The first value for the clearance, coinciding with the onset of water diuresis, is almost always higher than the later values. The values from the middle period of the tests at rest, after a drop in the diuresis rise, are close to 80 cc/min, i.e., 5 cc above the van Slyke mean value, which might be due to the fact that our test subjects were all tall and muscular individuals.

The influence of muscular work on the urea clearance is clearly discernible in all tests; the renal function drops considerably, with the decrease being 25 - 75% compared with the corresponding value of the control test.

During the afterperiod, a recuperation of the renal function usually takes place. Only three times was this recuperation absent and twice did a slight decrease occur after the working period. These were test subjects who had exercised strenuously.

The amount of water excreted in unit time had to be determined for calculating the clearance. This behavior is of some importance for our problem since it is used frequently as a criterion in observations of the effect of muscular work on the renal function. Our tests clearly show the unreliability of this criterion. In most cases, the reduction in water elimination is a multiple of the restriction of the true renal function. Whereas, after the work, the urea clearance generally recovered the amount of water decreased further, which most likely could be attributed to losses by perspiration. In one case, constancy was observed during the working test and in another case a considerable increase in water elimination. The strong individual fluctuations, despite equality /146 of the conditions at the beginning of the test (fasting, time of drinking, amount of drinking, bed rest) make a quantitative determination of the water elimination, for an evaluation of renal function tests during heavy muscular work, quite impossible.

The question as to the cause of the renal function disturbance, demonstrated here, must be left for later investigations. Presumably, as already assumed by Ranke (Ref.1), changes in blood distribution are involved.

Summary

The renal function during muscular work was investigated in 10 healthy test subjects, using the urea clearance method. A decrease in renal function by 25 - 75% during work was observed. Consequently, determinations of urea clearance for diagnostic purposes should be made only at bed rest. The behavior of water excretion, as a criterion for renal capacity during muscular work, is unreliable. Water excretion (presumably by extrarenal processes) is influenced in a more irregular, stronger, and lasting manner than the urea excretion function.

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